# EXPLANATION OF NULL RESULT OF MICHELSON AND MORLEY EXPERIMENT BY STUDYING THE BEHAVIOUR OF WAVEFRONTS OF LIGHT

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## ABSTRACT

Michelson and Morley experiment was conducted in the year 1887 to measure the velocity of earth. In this experiment Michelson interferometer was used in which two rays of light are superimposed to generate interference fringes. The experiment is based on wave nature of light and interference pattern is observed in the telescope. The velocity of earth around the sun is 30 km/sec and a fringe shift of 0.44 fringe was expected on the rotation of interferometer at an angle of 90° at this velocity of earth, but no fringe shift was observed in this experiment. A number of explanations for null results were given, but no one was found to be correct. The null result of this experiment could not be explained by classical mechanics.

The failure of Michelson and Morley experiment led to the development of special theory of relativity. As per S.T.R. light travels with Constant velocity in both the arms of interferometer irrespective of motion of light source or the observer and no time difference is involved between the two ray hence null result of MMX has been explained.

In the present article it is demonstrated that null result of the MMX Can be explained by studying the behaviour of plane wavefront of light

**KEYWORDS:** Interferometer, Fringe Pattern, Ray of Light, Mirrors

## EXPERIMENT

In Michelson and Morley experiment plane wavefront of monochromatic light is made to fall upon a glass plate and ray of light is splitted into two parts by semi-silvered glass plate, both the rays of light travelling at right angles to each other are reflected by two mirrors placed at equal distance from the glass plate and are reunited at the glass plate and interference pattern is formed which is detected through telescope. One arm of the interferometer is adjusted in the direction of motion of earth and the other in perpendicular direction as shown in Fig I below.

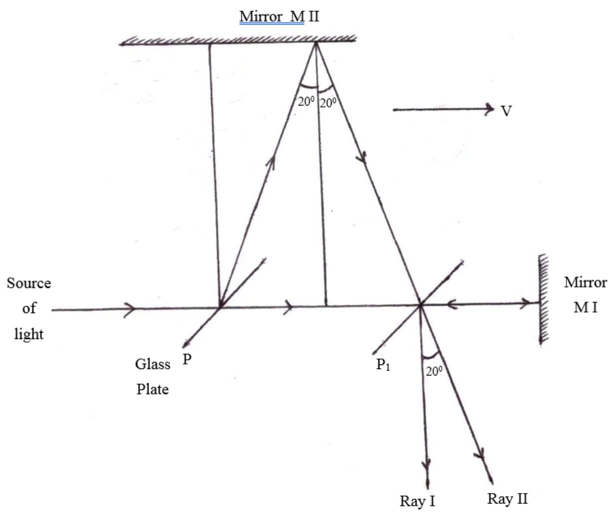


**Figure I: Let Angle between two wavefronts is 20⁰**

Let the velocity of light be c and velocity of earth be v. The mirrors MI and MII are situated at a distance L from glass plate P. The time taken by ray I going towards mirror M1 is calculated as under time taken by ray of light from glass plate P to mirror $M_1$ is

$$t_1 = \frac{L}{C-V}$$

time taken by ray of light from mirror $M_1$ to glass plate P is

$$t_2 = \frac{L}{C+V}$$

The total time taken by light ray from P to $M_1$ and $M_1$ to P will be $t_1 + t_2$

$$\text{hence} \quad t = t_1 + t_2 = \frac{L}{C-V} + \frac{L}{C+V} = \frac{LC+LV+LC-LV}{C^2-V^2}$$

$$\text{therefore} \quad t = \frac{2LC}{C^2-V^2} = \frac{2L}{c}\frac{1}{\left(1-\frac{V^2}{C^2}\right)} \qquad \text{I}$$

The time taken by light ray II going towards mirror MII is calculated as under,

By the time ray of light going towards mirror MII reaches at the mirror. The Mirror has moved by distance $vt_1$ hence light ray has adopted cross stream path to reach mirror MII as shown in

fig I above. The distance travelled by ray of light is $ct_1$ by using Pythagoras theorem

$$(c\,t_1)^2 = (v\,t_1)^2 + L^2$$

$$t_1^2\,(c^2 - v^2) = L^2$$

$$t_1 = \frac{L}{\sqrt{c^2-v^2}} = \frac{L}{c\sqrt{1-\frac{v^2}{c^2}}}$$

same time will be taken by the ray of light from mirror $M_{II}$ to glass plate P

$$t_2 = \frac{L}{c\sqrt{1-\frac{v^2}{c^2}}}$$

Total time $t = t_1 + t_2 = \frac{L}{c\sqrt{1-\frac{v^2}{c^2}}} + \frac{L}{c\sqrt{1-\frac{v^2}{c^2}}}$

therefore $t = \frac{2L}{C}\,\frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$ ______II

the difference of time between ray I and ray II will be

$$\Delta t = \frac{2L}{C}\,\frac{1}{1-\frac{v^2}{c^2}} - \frac{2L}{C}\,\frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$= \frac{2L}{C}\left(1+\frac{V^2}{C^2}\right) - \frac{2L}{C}\left(1+\frac{V^2}{2C^2}\right) \quad \text{Applying binomial theorem}$$

$$= \frac{2L}{C} + \frac{2L\,V^2}{C^3} - \frac{2L}{C} - \frac{L\,V^2}{C^3}$$

$$= \frac{L\,V^2}{C^3}$$

The path difference between ray I and ray II will be $\frac{L\,V^2}{C^3} \times C = \frac{L\,V^2}{C^2}$ When the interferometer is rotated at 90 degree angle the path difference between ray II and ray I will be $\frac{LV^2}{C^2}$ and total path difference will be $\frac{2L\,V^2}{C^2}$ the expected fringe shift at this path difference has been worked out to be 0.44 fringe, but no fringe shift was observed by the experiment. No successful explanation has been submitted for this null result by classical mechanics so far.

Two different wavefronts of light spherical or plane may be used in the MMX. If spherical wavefront of light is used than no fringe shift will be observed on rotation of interferometer at 90 degree angle as described in my article published in IERJ vol (4) 2024 page no 13 to 15. Let us discuss when plane wavefront of light is used, when interferometer is rotated at 90 degree angle the pathways of ray I and ray II exchange as shown in Fig II and III below

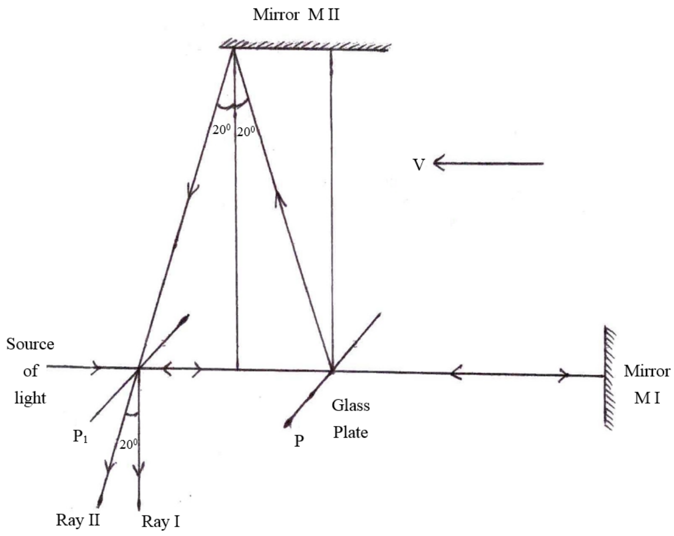


**Figure II: Angle between two wavefronts is $20^0$**

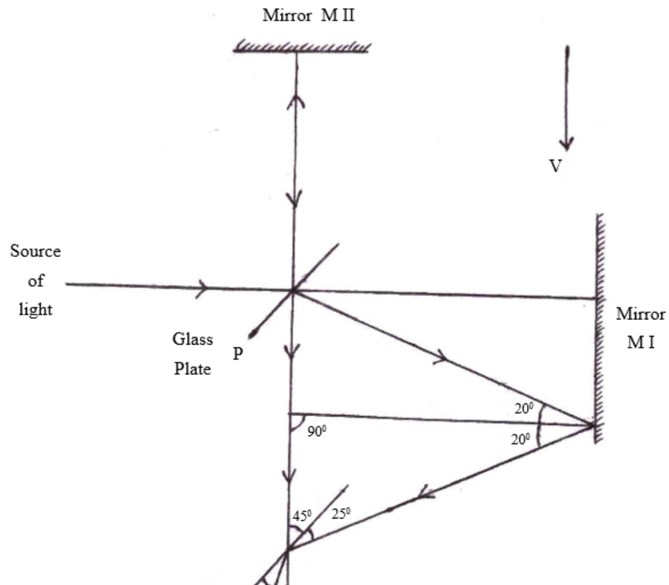


**Figure III: Angle between two wavefronts is $20^0$**

The place of ray I is occupied by ray II and vice-versa without any shift in the interference pattern. After reflection from Mirror MI and MII the virtual sources of light ray I and ray II will be back and forth in front of observer screen. Both the rays are travelling at right angles to each other and are reunited at the glass plate P. On rotation of interferometer twisting of wavefronts starts simultaneously to occupy places of each other and the two rays effectively swap places, it means behaviour of wavefront of ray I will be executed by wavefront of ray II and Vice-versa. Since rays swapped places there optical path remains the same due to symmetry or reciprocity principle in interferometry. The symmetry of interference ensures that fringe pattern will. remain unchanged and no fringe shift will occure.

The null effect of interference pattern is demonstrated below in geometrical diagram of pattern in Fig IV and it is explicit that there is no fringe shift in the interference pattern on rotation of interferometer at 90 degree angle

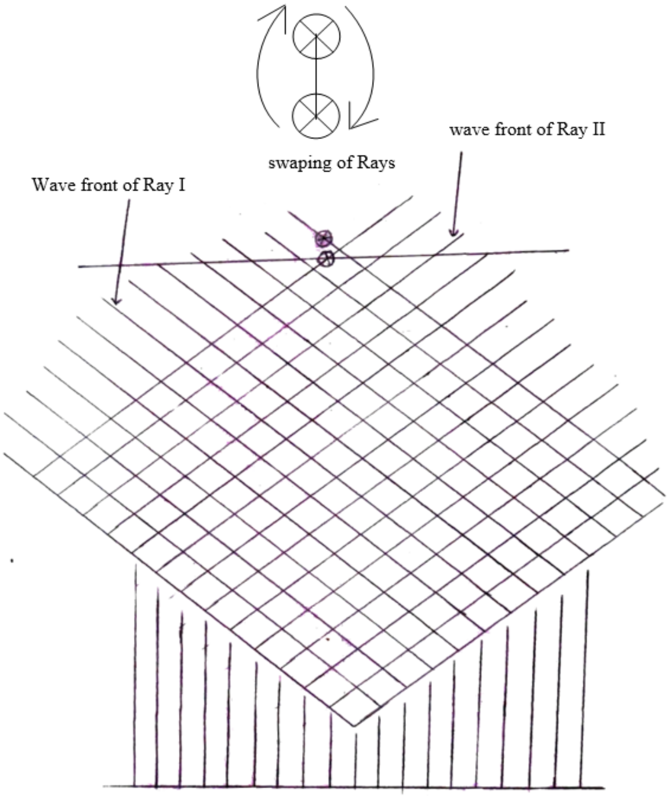


**Figure IV: Interference pattern on Screen**

## CONCLUSION

Both the rays of light in The Michelson and Morley experiment swap their places automatically on rotation of interferometer, hence fringe pattern remains the same because behaviour of wavefronts is exchanged. The ray I plays the part of ray II and ray II plays the part of ray I in similar manner resulting in to zero fringe shift on the rotation of interferometer at 90 degree angle and the result of MMX is in accordance to classical mechanics.

## REFERENCES


1. Dharam vir Singh. Explanation of null results of Michelson and Morley experiment by classical mechanics part II ierj 2024, 10
2. Explanation of null result of Michelson and Morley experiment by classical mechanics TIJER Vol 10 issue 12, December 2023, Regd. ID TIJER 150626